LEVERAGING INFORMATICS TO UNDERSTAND ONLINE COMMUNICATION PATTERNS BETWEEN MIGRAINE SUFFERERS ON SOCIAL MEDIA

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Historical Background and Growth

Healthy People 2020, a group of 10-year national goals for enhancing the American peoples' health, listed the field of health communication and health information technologies as a critical field for attention for improving individuals' health outcomes and attaining health equity [1]. The up rise of health-focused social media platforms users is expected to increase in the next few years.

In 2010, Kaplan and Haenlein defined social media as "a group of Internet-based applications that build on the ideological and technical foundations of Web 2.0 and that allows the creation and exchange of user-generated content [1]. According to O'Reilly, Web 2.0 was defined as "a set of economic, social, and technology trends that collectively form the basis for the next generation of the Internet, a more mature, distinctive medium characterized by user participation, openness, and network effects [2]. The difference between Web 1.0 and Web 2.0 is "interaction". Web 1.0 is one-way communication while Web 2.0 enables the user to create content on the web that explains the reason for the increasing amount of "user-generated content" [3]. Application of Web 2.0 technology in the health care domain led to the emergence of the term "Health 2.0" while others used the term "Medicine 2.0" [3]. The escalating emergence of Web 2.0 technology and the rapid adoption of social

media tools offered a valuable opportunity for patients to get more involved in managing their disease conditions [4]. Examples of social media tools include social networking sites (SNS) such as Facebook, LinkedIn (business networking site), YouTube (video sharing), Flicker and Instagram (photo sharing) and a microblogging site like Twitter. According to Merriam- Webster website; microblogging was defined as “blogging is done with severe space or size constraints typically by posting frequent brief messages about personal activities”.

Relevant statistics

Social media is a communication mechanism that enables users from all over the world to connect [5]. More than 60% of internet users utilize Facebook and Twitter [6]. The use of social network sites is recognizable. In 2011, Pew Internet Research Foundation highlighted in their report that 8 out of 10 individuals in the United States use the Internet to seek health information. Based on that percentage, almost a third of the U.S. adult population use SNS like Twitter and Facebook to exchange health information. In 2013, 73% of adults used a particular type of SNS and 42% of them participated in more than one. Facebook was ranked at the top (1.19 billion users/month) followed by Twitter (500 million users). The majority of participants in SNS are between the ages of 18-24 years [7][8]. Seniors, baby boomers, and Gen. Xer’s (born between

approximately 1961 and 1981) were more inclined to engage in online wellness groups than Gen.Y's (born between 1982 and 2001)[9]. According to the Pew Internet research report, Sixty-six percent of Adults searching for health information were looking for information focused on a particular disease condition while 44% of them were collecting feedback about healthcare professionals followed by hospitals (36%).

Understanding medical test results and reading about drug safety were the least topics that interested health information seekers (16% and 24 %). By 2007, Sillence et al. suggested that online user-generated content influences health-related decision making and impacts patient-physician communication. When it comes to serious medical conditions, people use search engines [10]. During the diagnostic search phase, people utilize both evidence-based search (symptoms focused) and hypothesis –based search (treatment focused).

Intended and Unintended Consequences

The use of social network sites (SNS) as an intervention has been significantly related to positive behavioral changes as in the case of anti-drug use, exercise, HIV testing, prevention of teen pregnancy, irresponsible driving and promoting healthy dietary practices[11][12]. The disease-specific online social network allowed patients to exchange emotional and informational support [13].

Patients participating in disease-specific social networks have seen improved psychological outcomes as in the case of breast cancer, Diabetes, Smoking and weight loss online support groups. Patients with diseases characterized by being socially isolated like HIV, STD, and mental illness have seen the same results as well. [14][15][16][17][18]. Still, there is no causal relationship between positive outcomes and using social media. Although most research studies proposed positive outcomes for using social media for the patients in different disease conditions, some scholars raise a red flag for the possible negative consequences. The spread of misinformation was pointed out in several studies [19]. Unintended consequences were pointed out by Hawn arguing that the nature of social media could contribute to the spread of personal information outside our circle of contact. On the other hand, Solove argues that an individual's behavior could be a major factor contributing to the diffusion of personal information [20].

All this research was conducted at the individual level using traditional statistical analysis while focusing on the patients' attributes and personal behavior including utilization of various social media tools. This individualistic perspective of research removes the person from his/her social context overcoming the influence of his/her connections. The other downside for this individualistic point of view is that it may not be capable of providing

answers or limiting the research questions from a social network perspective. However, the fact that people live in a web of relationships and connections (either offline or online) and are influenced by opinions, beliefs, and behaviors of their contact have encouraged researchers to use the network perspective as a new angle of research especially in the health domain [21][22]. Christakis and Fowler showed in a study that connecting with happy individuals impacts our happiness and is dependent on the degree of connection to those people [23].

Interventions are employing the power of peer influence or ” social networks” could be used as an intervention to spread positive health behaviors as in the case of tobacco and alcohol cessation and weight loss programs. These interventions are more successful than those who do not use the power of social

Network [21][24]. The reason for that was that individual perspective about his condition is formulated partially by others’ opinion. Another advantage of employing the power of the social network as an intervention could be viewed from a cost-effective perspective as the progress in one individual's health condition will spread to his social network. Social network research provides information about behavior distribution in a network and the factors related to behavior change. A recent systematic review (2014) by Laranjo et al. revealed that Face- book was the most used SNS in research either

combined with other interventions or as a stand-alone platform. Disease conditions studied included; Weight loss, Diabetes, Sexual Health and Food Safety [24]. Therefore, based on that utilization; Facebook was selected as the setting/ platform for this project.

Network structural properties and relation to behavior change

In the following section, we will briefly introduce some of the network characteristics and how it relates to online users behavior in previous research studies.

Network features include:

Actors or Nodes: represent an individual having connections with others.

Ties: refers to a particular relationship created between two **Actors or Nodes**.

There are two types of ties.

a) Undirected-Ties: in this case, it describes a relationship that two individuals share the same meaning as “joining the same online community” or “liking fast food”.
b) Directed Ties: it means “following” or “talking” to someone.

Size: defined as the number of members of the network. The size of the network is one of the primary structural network characteristics. The importance of it arises from the relation between other network variables like density.

Density: it is described as the number of ties calculated in a particular network as a fraction of the total links possible, and it measures the extent users of the network are connected. There is an inverse relationship between the size and the density of a network. Density is often calculated on sub-communities, and it reflects. A network with higher density indicates a more supportive and more engaging community.

Reciprocity: is the tendency for directed ties from actor i to actor j reciprocated and sent back from actor j to actor i. This captures the classic finding that feelings and actions tend to be reciprocated.

Diameter: of a network is the largest distance between any two nodes in the network.

Clustering Coefficient:

It is defined as the degree of aggregation or clumpiness of the nodes in a network. In other words; it reflects the degree to which my friends are friends with one another. Clustering helps in identifying groups that are considered one of the successful interventions regarding introducing and promoting new behaviors to a group. For example, members of an online cancer support group forum were more involved in discussions focused on treatment options than the symptoms [25].

On the other hand, newly diagnosed diabetic patients participating in

the online social network were more active throughout the first year of joining the forum then became less active later. However, still, the dynamics of the diabetic community was higher and revealed greater cohesion when compared to other non-health-related social networks.[26] The study also showed that newly diagnosed diabetic patients clustered around patients who had diabetes for more than two years which indicated their need for information from the “expert patient”[25]

Migraine

A migraine is a chronic neurological disorder with repeated moderate to severe episodes of headache that could last from a few hours to a few days impacting the individual’s daily routine. Symptoms include; pain associated with nausea, and increased sensitivity to light and noise among the common symptoms accompany migraine headaches. One of the common symptoms that precede the onset of the migraine episode in approximately 30-35% of patients is an “Aura”. An aura affects the patient’s vision and results in partial vision loss, colored flares and flashes. Other symptoms include; weakness or tingling in some parts of the body and difficulty to talk, comprehend or engage in a discussion [27]. Migraine was and still an under-recognized chronic disease characterized by high morbidity and cost [28][29][30]. The World Health Organization announced migraine as one of the top-rated

severe chronic conditions (WHO, 2004) still society underestimated by patients' connections like their managers, co-workers, friends and family

Members [31] Migraine is one of the diseases that need much self-care from the patient, in other words, the patient needs to identify their migraine triggers, symptoms, and effective treatment methods. In general, there is an inadequate understanding of the severity of migraine suffering and its impact as a public health issue. Although Migraine affects 12% of the adult population in the U.S. with higher prevalence in women (18%) than in men (8%) impacting their mood, productivity in work and social life [32], underdiagnosing is still a major problem. In 2004, Gallagher revealed that 50 % of patients remain underdiagnosed due to deficiency in therapeutic consultation in general for headaches [33]. Similarly, migraine patients don't check with their physician for their headaches as well [34]. Stovner & Queiroz (2011:38) in their work emphasize the lack of appropriate resources to migraine treatment and prevention, also inadequate focus in the medical school curriculum and finally not enough funding available for more research [35]. Migraine impacts the individual's social life as it constrains their ability to participate in social meetings and get involved in relationships [36]. They wouldn't even get out of their homes due to the fear of having migraine [37][38]. From a societal perspective, migraine affects individuals during their peak

productive life reducing their work functionality, increase absenteeism [39]. Migraine treatment is challenging because it relies on patients' retrospective story. After all, usually, migraine patients seek help after the migraine episode is over. Another challenge is the short time visit which constrains the ability of the patient to adequately describe the symptoms.

Treatment of migraine has been classified into two main categories: pharmacological and non-pharmacological. Pharmacologic treatments are categorized into medication that is administered at the beginning of the episode and medications that are taken daily to avoid the migraine and minimize the severity of it. Patients' adherence to these medications varies tremendously. With poor physician-patient communication, patients are left with a lot of unmet needs and suffering. The non-pharmacological treatment is based on educating the patients about triggers, symptoms, and possible lifestyle changes to cope with the migraine episode. Advice includes eating healthy, avoiding a certain type of food, stress, regular sleep, and exercise.

In this study we decided to study a migraine for several reasons:

1) Migraine is understudied in the disease-related social network sites literature despite its unique characteristics and challenges [Cancer, diabetes, and HIV are highly investigated in the social network literature]

2) Relies basically on a patient's self-reporting of triggers, symptoms, coping strategies and medications
3) Unpredictable and intermittent episodes.
4) Informational and social support is required to assist migraine sufferers to cope with their disease condition.

Migraine Management is different from other chronic illnesses as it requires the patient to alleviate pain and reduce the attack period. There is a need

for more studies to understand migraine patients' behaviors in different social media tools. A recent study (2013) investigated migraine sufferers' behaviors on Twitter revealed that some women tweeting on migraines were more than men, and these tweets were on weekdays more than weekends, and users reported information about triggers of migraine [40]. Although migraine management has been extensively explored in the medical literature, there is still a need to address the importance of the use of technology to assist migraine sufferers to cope with symptoms [41]. The current technology includes mobile applications that aim to help migraine patients to track triggers, symptoms, frequency and the duration of the migraine episode. Migraine patients found more benefits from using electronic diaries over the traditional method (paper-and-pencil) in monitoring the effectiveness of over the counter analgesics [41] while using a website designed online training for

migraine management before the clinic visit had a positive impact on the patient-physician relationship [42]

Literature Review

In the following section, a literature review was completed using the following database: Academic Search Premier, Business search Premier, JSTOR and Google Scholar. The review utilized the keywords; social media, social network sites (SNS) and behavior change, health, patient, online community.

The selection of the proposed databases was due to the existence of a vast amount of information and robust studies that are highly relevant to the thesis objective. Studies reviewed were from different disciplines like Computer Science, Information Systems, Organization and management literature, business, marketing and communication studies. Access to these resources was available through the School of Pharmacy and Carlson School of Management databases. The review will go over studies that employ social network research in the health field in general then narrow it down to studies used Facebook and Twitter as the context for their research, and that is also related to the thesis objective. Valente in his book “Social networks and Health” revealed the reasons for the growth in social network research as it provides information about behaviors distribution in a network and the factors

related to behavior change as the following:

a) Availability of a different perspective for viewing health issues and changes in

b) health behavior; for example, it explained quitting smoking due to the influence of social ties

c) The advance in communication technology like cell phone, the internet has expanded individual's networks beyond family, neighbors and friends

to include geographically distant relations. Therefore, it became a part of people's daily life.

d) The emergence of new and available software made it easy for researchers to apply social network analysis techniques to different disciplines.

e) Network analysis enabled researchers to understand deeply and apply the information gained to encourage positive behavioral changes or reduce the consequences of the spread of negative behaviors.

Social network research in the health domain

The escalating rise of social media channels contributed to the shift in paradigm from traditional patient to a new model of highly pro-active "e-patient". E-patients are actively seeking information

than communicating with their doctors [43]. In a recent review on the impact of SNS on health behavior, revealed that obesity and physical activity were at the most studied conditions [11]. Disease-specific support groups allow patients to exchange knowledge about the disease and provide emotional to others who undergo the same situation. In general, online health support groups could be categorized into two types:

1) Independent or stand-alone health communities like Patients Like Me or MedHelp.
2) Health communities built on famous network sites like Facebook, Twitter [44]

The current thesis will focus on the second type; where health communities are built on Facebook and Twitter. The reason is the high utilization of these two particular SNS (Facebook and Twitter) where 67% of internet users are inclined to use Facebook & Twitter [6]. Connections on these platforms are viewed as digital extensions of already existing relationships which increase access and discussion to health information either online or offline. Also, health communities built on these social network sites are more likely to reach out to a wide range of audiences regardless of their socio-economic background and health conditions [20].

Principles of the social network research are built upon the graph theory in which users are considered as nodes in the network, connected by ties/edges (i.e. what they exchange between each

other like an exchange of knowledge or emotional support). Social networks represent the bonds that unite us as individuals to organizations, society, family and groups [45]. Individuals connected by weak ties tend to share information and resources, and mostly they are different from each other (i.e. don't share the same habits, friends, and resources) [21]. Social network analysis was utilized in several studies to examine the dynamics of the social network; understand the evolution and patterns of development of the community over time [26]. For example, members of an online cancer support group forum were more involved in discussions focused on treatment options than the symptoms [46]. On the other hand, newly diagnosed diabetic patients participating in the online social network were more active throughout the first year of joining the forum then became less active later.

However, still, the dynamics of the diabetic community was higher and revealed greater cohesion when compared to other non-health-related social networks. The study also showed that newly diagnosed diabetic patients clustered around patients who had diabetes for more than two years. The author explained that the need for information from the "expert patient" was the reason for this clustering phenomenon.[47][48][18]. People tend to build relations and adopt behavior with those who are similar to themselves, share the same interests, opinions and socioeconomic background that is

known as “Homophily.” There is a debate in the literature whether people change their behaviors as a result of selection (clustering of similar individuals) or social contagion (adopting a particular behavior as a result of their peers ‘influence who already support or perform the same action). In 2007, Hall and Valente used the tie direction as a measurement to differentiate between selection and influence. They proposed that ties coming from a person (out-degree) represent “selection”; on the other hand, ties directed towards a person (in- degree) represent “influence.”

Social networks affect an individual’s health by providing informational, social, technical, and appraisal support that could assist an individual’s capabilities to cope with anxiety associated with different health conditions resulting in better outcomes [49]. Social influence significantly contributed to positive health outcomes in the case of the smoke cessation group [17]. Participants in an online weight loss community lost more weight as their number of friends increased and as their friends lost more weight as well [50][51]

Cancer patients felt less stressed after joining an online cancer support group [51][52]. Also, it was found that online health information seekers' views are influenced by others' opinions when they read on different websites. Even research done in other

disciplines showed that online political views affected others' voting behavior [53][54].SNS users formed online communities for specific health issues and disease conditions. For example, a recent study on Facebook and Twitter found 527 diabetes groups, 216 breast cancer groups and 171 colorectal cancer groups.

In general research on Twitter especially in the health, the domain is still in its early stages. Few studies have been done suggesting that the platform could be useful for accessing real-time data and analyze conversations regarding various health conditions like tracking flu trends, misuse of antibiotics [23]. Analyzing content generated by Twitter users (Tweets) has been the focus of research in the health domain as in the case of dementia, cancer and drug abuse [60]. Another interesting study used geotagged tweets to identify areas characterized by high psychological well-being like happiness across the US [55]. Twitter is fit for exchanging information rather than emotions because it operates more as a disseminating channel than an interactive tool. The most popular health-related topics on Twitter classified them into were three groups: Health promotion, Disease conditions, Professional communication.

While messages on Twitter had three main themes:

1) Opinions or facts (Posted by support groups)
2) Informational (disease information- posted by health

agencies like CDC or Drug companies.

3) Emotional (posted by the public).

Theoretical framework

The power of social network theory is built upon the hypothesis that the structure of the individual's network impacts their opinions, beliefs and behavior. The number and layout of connections an individual has controlled the access to available resources (information, emotional and network). For patients with chronic disease, there is more involvement from the patient to find new strategies to cope and manage their condition [56]. Patients follow a variety of coping strategies; one of them is to gain more information about the disease. Another strategy is to communicate and build relations with those going through the same disease condition.

Information-Community-Action framework

One of the frameworks that have recently been applied to studies focusing on analyzing health-related conversations on Twitter are "Information-Community- Action framework" [57]

1- Information: includes tweets that express facts about the disease, opinions, or stories.

2- Community includes tweets that aim to emotional support.

3- The action includes tweets adopting performing a particular behavior.

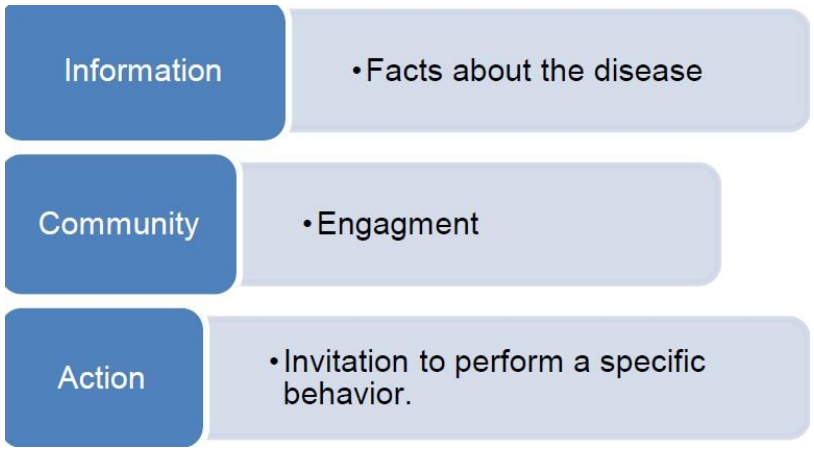


Figure 2. 1 Information- Community- Action Frameworks

Content Analysis

The use of content analysis technique was beneficial in identifying the different types of social support from a discussion between participants. The goal of using content analysis was to attain a general understanding of certain behavior or issue and results in developing specific concepts or themes of the investigated behavior or condition [58]. There are two kinds of content analysis, inductive and deductive content analysis. The inductive content analysis utilizes open coding to document text and categorizes into specific themes while deductive content analysis implement is already existing codes into a different context. The deductive content analysis also tests the hypothesis.

For example, posts of Alcoholism community on Med Help

were analyzed and developed a coding scheme for social support and proposed three types of social support including informational, emotional and instrumental support [59][60]. Another study, to identify Informational and emotional support offered and/or received in online obesity that helped participants cope with their condition [61]. Analysis of messages of an online disability community revealed the emerging of two themes: task-oriented posts and socio-emotional posts [62]

Statement of the Problem

All this research was conducted at the individual level using the traditional statistical analysis while focusing on the patients' characteristics, personal behavior, and utilization of various social media tools. However, the fact that people live in a web of relations (either offline or online) and are influenced by opinions, beliefs, and behaviors of their contacts [21][22] have encouraged researchers to use the network perspective as a new angle of research especially in the health domain.

Research Gap

Although there is increased attention in the literature focusing on the use of SNS in the healthcare field and related behavioral changes [63], yet there is a gap in describing the structure of these networks and how it relates to users communication patterns and change in behavior [64][65]. There is a call for more research on

how the structure of individual social networks impacts behavior change instead of just studying the mechanisms that lead to behavioral change like social support [66]. Characteristics of an individual's social network influence their health behaviors. For example, structural properties, heterogeneity, the number of close contacts and the degree of separation, access to resources, social support and social influence. These results were used by researchers to support the use of SNS in stimulating health behavior changes [67][68][26]. Furthermore, another gap in current research is that most of the studies are focused on a single platform or site overlooking comparison between different types of social media platforms, differences in users' communication patterns, needs and how it impacts their behavior. Therefore, comparing two different health-focused SNS for the same disease will lay a foundation for further investigation to provide answers to the following questions:

1- Are particular SNS (Twitter vs. Facebook) related to positive behavior changes for a specific disease?" and why?

2- What are the motivations or factors that impact a user decides to join one or more social media platform and to what extent their needs are satisfied?

Addressing these research questions will help improve and create efficient disease-specific SNS that will meet the patient's needs.

Valente identified several strategies to utilize SNS best as an intervention to promote healthy behavioral changes [69]

Purpose of the Study:

This multi-faceted study will gain a deeper understanding of differences in patients' behavior across two social media platforms for the same disease (migraine in this study). This study will take a further step to uncover the reasons that impact patients to select a particular social media platform and what are the benefits they gain? It is important to characterize the social network structure and ties' characteristics between users on each platform whether it is associated with better health outcomes. It is critical to comprehend: who communicates the information, with whom, about what and using which media platform.

Research Questions

The overall goal of this project is to understand the differences in structural and behavioral characteristics of two different social media platforms. Also, the study aims to gain deeper insight regarding the motivations that impact patients' decision to join a particular social media platform. Specifically, the study will identify the differences between network structure and tie characteristics between the two a migraine social network sites (SNS) and how it impacts patients' coping strategies to manage their condition. Results will provide the foundation of knowledge serving future

investigation to improve the effectiveness of SNS interventions to help patients better according to their customized needs. We propose the following research questions:

RQ1: Are there differences in characteristics of "**network structure**" between migraine communities who use Twitter and Facebook?

Network characteristics are Density, Centrality and clustering measures.

RQ2: Are there differences in **"ties characteristics**" between migraine communities who use Twitter and Facebook?

Tie characteristics are Reciprocity and Strength (Repeated Tie Fraction).

RQ3: What are the "**engagement patterns**" for migraine communities who use Twitter and Facebook?

The findings from the current study focusing on migraine patients' behavior on different social network sites will provide a wealth of raw, real-time data for researchers, health professionals, and decision-makers. The results of this study will lay the foundation for further research to understand online patient behavior on various social media platforms to improve the effectiveness of social network interventions by addressing patients' needs and encouraging the spread of positive behavior changes.

Methodology

While traditional social science research methods pay attention to individuals and their characteristics and personal behavior, network research methods investigate relations connecting individuals without considering their attributes. The social network is defined as a social structure consists of individuals known as “nodes” linked to each other “ties”. In this research, we are attempting to describe the structure and connection patterns of online patient communities or communities on two different social media platforms Facebook vs. Twitter.

Guided by the study objective and proposed research questions, traditional statistical analysis would not be useful for the network perspective approach of the study. Therefore, the social network analysis technique was implemented to address the study objectives and research questions.

Despite the use of social network analysis (SNA) emerged in the social sciences almost a century ago, yet, recent research in the health domain started applying social network analysis to examine the dynamics of online health networks [26]. Social network analysis has been utilized in studies in diverse disciplines like Computer Science, Marketing, business, organization, and management literature. Social network analysis utilizes the “network” as the main construct. A network is a group of nodes/actors that are connected

by dyadic ties (tie created between two individuals). Nodes can be any type of entity, organization, or individual. Ties are hypothesized social relations created when any interaction occurs (for example; talks to). Ties are connected to a certain node to create a path. Several paths come together to form a unique structure that has an impact on the node/individual's behavior, information flow which controls opportunities available.

Connectivity: In this study, we selected to focus on network connectivity as one of the structural characteristics. Connectivity is closely related to the dissemination and accessibility of different resources by members in the network. Members of these highly connected networks consume/read content shared by other members. In high connected networks; information is dispersed rapidly than less connected ones. Connectivity helps in identifying groups which are considered one the successful interventions regarding introducing and promoting new behaviors to a group

For example, Members of an online cancer support group forum was more involved in discussions focused on treatment options than the symptoms [46]. Newly diagnosed diabetic patients participating in the online social network were more active throughout the first year of joining the forum then became less active later. However, still, the dynamics of the diabetic community was higher and revealed greater cohesion when compared to another non-health-related social

network. This study also showed that newly diagnosed diabetic patients clustered around patients who had diabetes for more than two years which indicated their need for information from the “expert patient”[18]. There are several measurements to assess the “connectivity” of a network such as density, diameter, clustering, and reciprocity and tie strength. To gain a complete understanding of the network connectivity from two different views so we decided to select the measurements from two different levels:

a) The network level: such as density and the clustering coefficient
b) The individual/dyadic level: reciprocity and the tie strength.

Research Design

The extraordinary advancement and utilization of technologies supporting social interaction are one of the marvels of this era. Billions of individuals all over the world now are using a diverse set of emails, text messages, blogs, online communities, video and photo sharing streams, social network sites like Facebook and Twitter. The rapid development of mobile devices aced the access to these social interacting tools. In the case of patients as users of these tools, Face- book and Twitter were the most social media platforms used for research studies [59].

To the best of our knowledge, this study is the first to describe and better understand differences in patients’ behavior

across two social media platforms for the same disease (which will be a migraine for this study). This led to select- ing the descriptive research design due to the lack of previous studies done and to address the study objectives and research questions. In the following section we will describe both platforms:

Facebook

Facebook was first launched in February of 2004, Facebook's mission “is to give people the power to build community and bring the world closer together. People use Facebook to stay connected with friends and family, to discover what's going on in the world, and to share and express what matters to them”. The gigantic on social media platform has an average of 1.56 billion daily active users (DAUs) as of March of 2019 [70]. In 2011, a study estimated a most Facebook users have an average of 190 relations or friends while the median number of friends for global use is 99 [71]. Facebook has been used as a context to study online patient behavior in various disease conditions [24]. For this study, the “Migraine.com” Facebook page was selected. It is the biggest online migraine on Facebook

“Migraine.com” community on Facebook:

Migraine.com is one of the health support communities on Facebook that is dedicated to a migraine suffer. It is one of the social media platforms of the “Migraine.com” website. The page has more than 124,000 fans. The mission of the page is summarized

“We empower patients and caregivers to take control of migraine disease by providing a platform to learn, educate, and connect with peers and healthcare professionals**.**

Twitter

In 2006, an online social network platform that was launched allowing its users to create an account and share status updates of up to 140 characters identified as “Tweets” (this is the reason it is considered a microblogging platform). After posting the tweet, followers of this user will be able to reply and/or retweet (share it with their network/followers). These tweets are publically available for any user who has a twitter account and search for them. Twitter users utilize hashtags to discuss mutual interest issues which encouraged several studies to suggest that Twitter hashtags adopt the creation of “virtual communities” share a common objective or topic [6][7]. Hashtags are words or phrases prefixed with the symbol “#”. They are used for categorizing tweets about the same topics.

Data Collection

The emergence of innovative software made it easy for researchers to apply social network analysis techniques to different disciplines. NodeXL[a] was used to import, analyze and visualize the social media network. Data were collected from November 23rd-26th, 2016

a “NodeXL, the free and open add-in for Excel 2007/2010/2013. NodeXL is a project from the Social Media Research Foundation1, a not-for-profit organization

dedicated to creating *open tools*, *open data*, and *open scholarship* related to social media. NodeXL is a general-purpose network analysis application that supports network overview, discovery, and exploration2. The tool enables the automation of a data flow that starts with the collection of network data and moves through multiple steps until the final processed network visualizations and reports are generated (figure 1). NodeXL allows non-programmers to quickly generate useful network statistics; metrics and visualizations in the context of the familiar Excel spreadsheet (figure 2). Simple filtering and flexible display attributes can be used to highlight important structures in networks easily. NodeXL supports the exploration of social media with import features that extract network data from a range of data sources like personal email indexes on the desktop, Twitter, Flickr, YouTube, Facebook, Wikis and WWW hyperlinks (see figure 3). Other sources of data can be imported through text, CSV, or GraphML files". [72]

Data Analysis

The study is the first to use social network analysis (SNA) techniques to describe and compare the structure of the online migraine community on two different social media platforms (Facebook and Twitter). The study used NodeXL[a] to describe the structure of the network (size, density and cluster analysis) on two different social media platforms (Twitter vs. Facebook) for a specific disease (a migraine was selected for this project). Furthermore, the current project identified tie characteristics (reciprocity, strength) between users of online migraine communities. NodeXL was also used to download available public data on November 23rd-26th, 2016 from Facebook and #migraine on Twitter.

Social network analysis (SNA) was used to address the questions.

RQ1: Are there differences in characteristics of "network structure" between migraine communities who use Twitter and Facebook?

RQ2: Are there differences in "ties characteristics" between

migraine communities who use Twitter and Facebook?

To address the study research questions, the following variables were calculated:

1- **Density:** the number of links in a network counted as a fraction of the total links possible. Density is calculated as:

$$D = \frac{L}{N(N-1)}$$

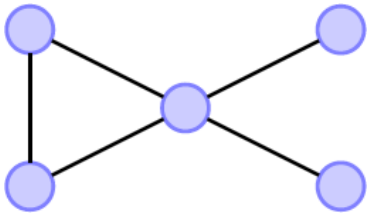
(L= links and N = size)

2- **Clustering Coefficient:**

Measures the degree to which nodes in a network tend to cluster together. Evidence suggests that in social networks, nodes tend to create closely tied groups characterized by a relatively high density of ties [73]. Clustering Coefficient assesses the degree to which actors form ties in dense, relatively unconnected (between groups) groups. The degree of clustering in a network is related to the efficiency with which information can diffuse over the network, as well as its robustness to disruption [74][75].

The individual clustering (*C*) for a node *i* is:

$$CC^{ii} = \frac{\text{Number of Triangles Connected to Node i}}{\text{Number of Triples Centered around Node i}}$$



The average clustering coefficient is:

$$C = \frac{1}{n}\sum_{i=1}^{n} C_i$$

Reciprocity

The inclination for directed ties from node i to node j to be reciprocated and sent back from node j to node i. Reciprocated ties indicate that people chose one another (not others) which leads to forming more clusters in the network. Reciprocated ties may also propose stronger ties, the inclination of engaging in the same behavior and agreed opinions and beliefs leading to more influence on each other's behavior. Reciprocity can be calculated as follows (Borgatti et al., 2006). Where A_{ij} indicates the link from i to j.

$$R = \frac{(A_{ij}=1) \text{and } (A_{ji}=1)}{(A_{ij}=1) \text{or } A_{ji}=1)}$$

3- Repeated Tie Fraction (RTF)/Strength:

Defined as the frequency of interaction between two individuals [76]) it is considered one of the most popular SNA variables but at the

same time not regularly applied in social media networks. Strong ties are related to more trust and an emotional connection between individuals [77]. On the other hand, Weak ties are often linked to information exchange [21]. The tie strength (Repeated Tie Fraction) is calculated by dividing the total number of duplicate edges by the total number of unique edges.

$$\text{RTF} = \frac{\text{The number of duplicate edges}}{\text{The number of total unique edges}}$$

Duplicate edges reflect multiple times of communication between two individuals (like answering questions back and forth during a discussion). See Figure 3.1(Figure 3.1 represents the unit of a network). That's if we zoom-in on Figure 3.2, we would get figure 3.1).The Information-Community-Action" framework was used as a guide to analyzing the content posted by users of migraine communities on Facebook and Twitter as in previous studies analyzing health content on social media [79]. Content with the disease information, advice, opinions, and experience will be coded under the Information category. Any comments with empathy or encouragement will be coded under the Community category. Finally, any call to perform a specific behavior or action comment will be coded as Action category [57].

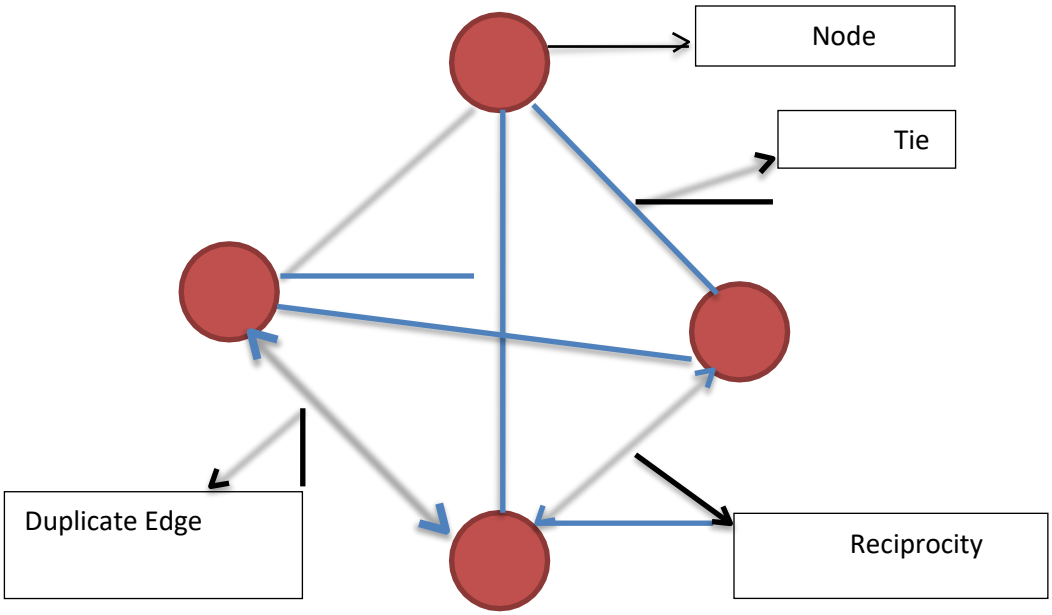


Figure 3.1 Visualization of some SNA terms used in the study

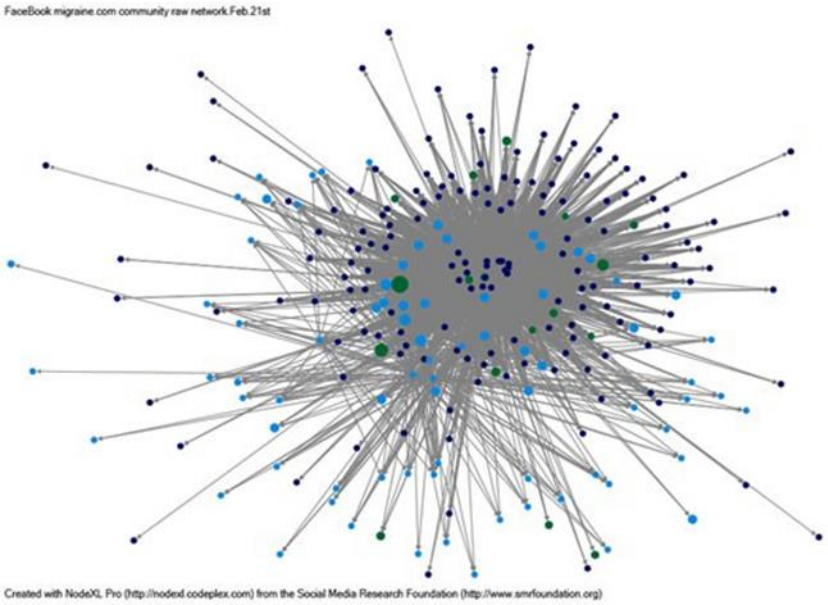


Figure 3.2 Visualization of the migraine community on Facebook

Figure 3.2
Visualization of the migraine community on Facebook

Content analysis

To explore and compare engagement/conversation themes between migraine patients on Facebook and Twitter, the content analysis technique was implemented. Content analysis was defined as “the systematic, objective, quantitative analysis of message characteristics.”[78]. Cleaning of the data on both platforms was performed before conducting the analysis. The data used is User-Generated-Content (UGC). UGC refers to any status updates or public messages posted by users on social media platforms on the internet). This process included:

a) Excluding all non-English content.

b) Removing all non-health-related content.

Eliminating all advertisements, spam and inappropriate comments: For example: Worse migraine ever and next door decide to start f***ing banging furniture around ☹

Results

The findings of the study will be displayed in light of the proposed research questions. During the Thanksgiving holiday (November 23-26, 2016) which is the study period; we used NodeXL to import the publicly available data from the migraine community on the “Migriane.com” Facebook page and #migraine on Twitter. It is important to mention that for the same study period; the Twitter community had 9,665 Twitter users whose tweets in the requested range contained "migraine", or who were replied to or mentioned in those tweets. However, only 292 out of 126,000 members (0.2%) of the Facebook migraine community actively participated in conversations creating 189 posts.

Graph Metrics	Twitter	Facebook
Nodes	9665	292
Unique Edges	9031	25146
Edges With Duplicates	2012	1649
Total Edges	11043	26795
Reciprocated Vertex Pair Ratio	0.03	0.02
Reciprocated Edge Ratio	0.06	0.04
Maximum Geodesic Distance (Diameter)	24	3
Average Geodesic Distance	7.6	1.4
Graph Density	4.7	0.3

Table 1

Results of Social Network Analysis on Facebook and Twitter

4.1 Network Structure Results:

To answer RQ1**:** Are there differences in characteristics of "network structure" between migraine communities who use Twitter and Facebook? To answer RQ1; we selected the Density and the clustering coefficient to compare the connectivity between the two migraine communities. For the density measurement, we found that the migraine community on Twitter had a higher density score than the Facebook one (4.7 vs 0.3). On the other hand, the clustering coefficient was lower for the migraine community on Twitter than Facebook.

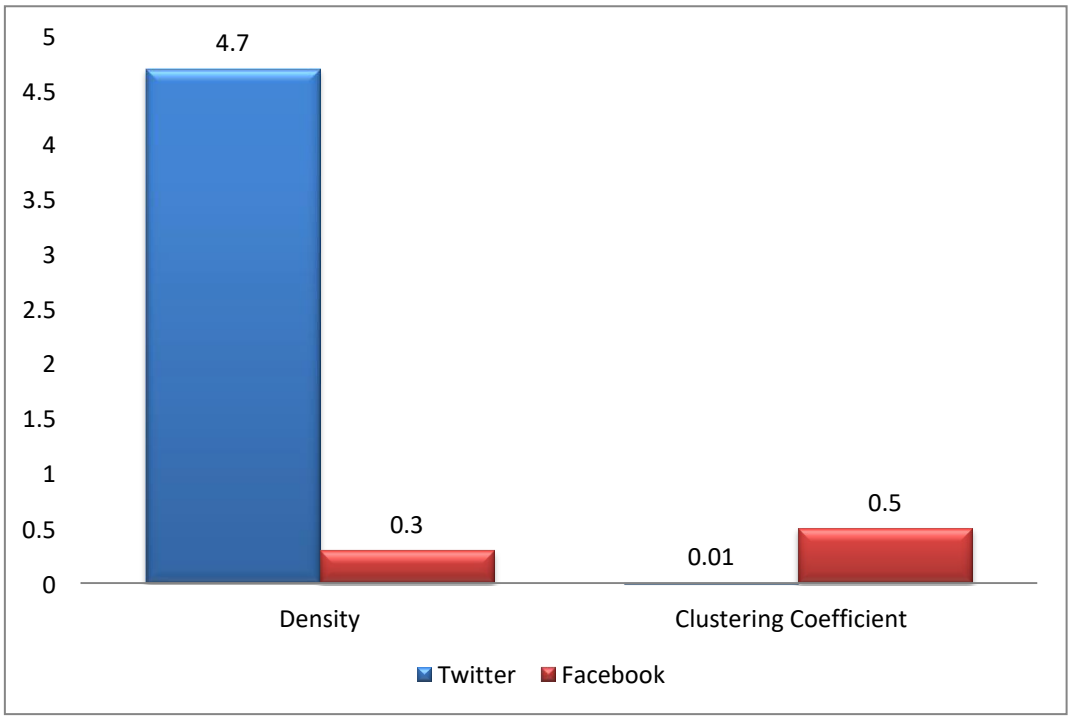


Figure 4.1

Measurement	Twitter	Facebook
Density	4.7	0.3
Clustering Coefficient	0.01	0.5
Reciprocity	0.03	0.02
Repeated Tie Fraction	0.2	0.07

Comparisons between Density and Clustering Coefficient on Twitter and Facebook

Table 2

Results of Connectivity Measurements for Facebook and Twitter

This shows that the members of the migraine community on Facebook are clumped in highly interconnected sub-groups than the Twitter migraine community as shown in table 4.2

4.2 The Tie Characteristics Results

To answer **RQ2**: Are there differences in "ties characteristics" between migraine communities who use Twitter and Facebook? We selected two measurements at the dyadic level which are the reciprocity and the Repeated Tie Fraction (RTF to assess the tie strength). The results show that at the dyadic (individual level); reciprocity between Twitter users is higher than Facebook community members (0.03 vs 0.02).

Following the same pattern, results of RTF (indicated the tie strength) was

higher for Twitter than Facebook (RTF=0.2 vs 0.07) as shown in Figure 4.3

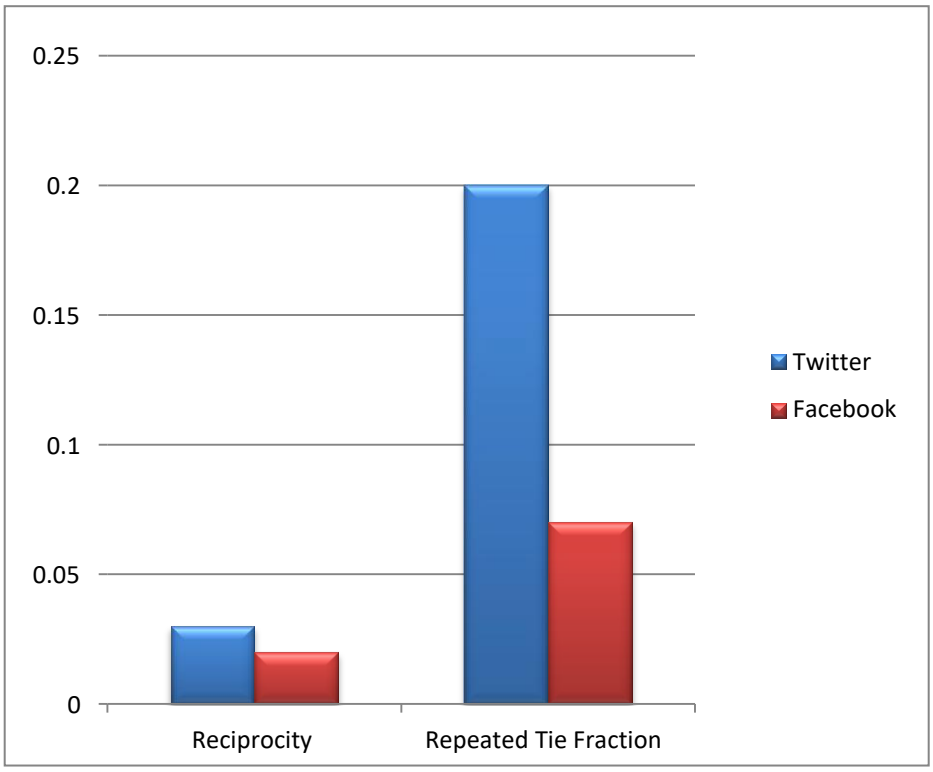


Figure 4.2

Comparing Tie characteristics between Migraine patients on Facebook and Twitter

Looking at the results for the first and second research questions; it is clear that there are differences in the network structure between migraine communities on Facebook and Twitter. From the network level; the migraine Twitter community is denser than Facebook. On the other hand, the subgroups on Twitter are less clumped/ clustered compared to the subgroups on Facebook. From the dyadic or the individual level, the ties between individuals on Twitter were stronger than those between Face- book community members. Subsequently, the reciprocity and the exchange of

information between Twitter users are higher than the Facebook participants.

So in summary, yes there were differences in both the network structure and the tie characteristics between both migraine communities on both Twitter and Facebook. In figure 4.3, we can visualize the migraine community on Facebook during the study period using NodeXL. Nodes represent users of the platform and an edge is created between two users when they interact with each other. These interactions could be either a “comment”, “reply” or using any of the emoji buttons to express certain feelings. Users of the community are represented by nodes which are varying in sizes based on the betweenness centrality score. The bigger the size of the node the higher score. This betweenness centrality score is reflective of the influential and the leadership role of the user. The biggest node was the migraine.com Facebook page moderator which make sense because they are the only one authorized to make a post while the rest of active participants can respond to the post or each other by commenting, liking or using any of the emoji buttons (like, sad, happy, angry). In Figure 4.4, Cluster analysis was conducted to migraine.com community on Facebook during the same study period. The graph's nodes were grouped by cluster using the Clauset-Newman-Moore cluster algorithm. The network was laid out using the HarelKoren Fast Multiscale layout algorithm. Cluster analysis helps identify subgroups in the community and how they are laid out. The cluster analysis revealed the existence of three sub-communities. The node sizes correlate with the betweenness centrality

scores in other words we can identify the most influential participants in each subgroup.

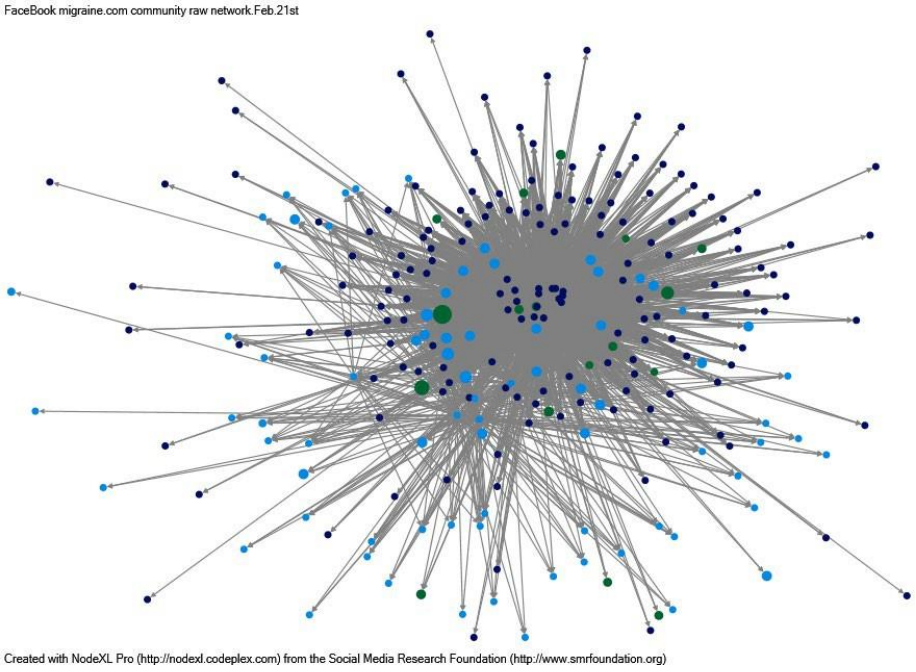


Figure 4. 3

Visualization of migraine community on Facebook (before conducting cluster analysis)

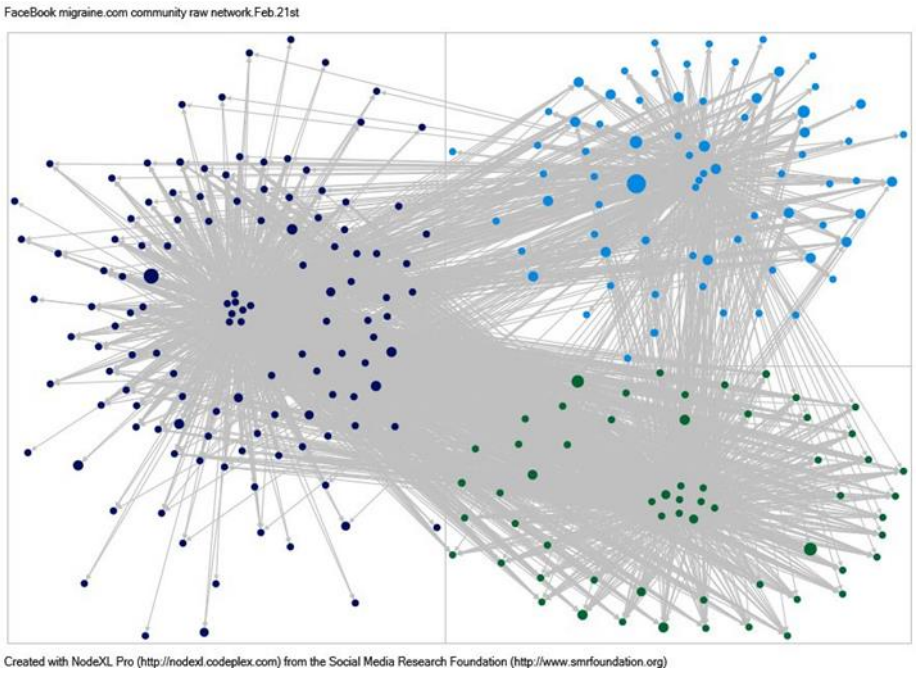


Figure 4. 4

Cluster analysis of migraine community of Facebook

In Figure 4.6, the analysis of the various engagement patterns of migraine.com Facebook page users revealed that migraines were more inclined to support each other using the ”Like” button which was about 62% vs almost 38% of commenting on the posts. To get deeper into the analysis, we identified the percentage of comments created and received to evaluate the engagement between users. There were no many differences in the percentage of comments created and received which were 21% and 17%. This reflects healthy engagement patterns between users. Although users preferred to use the “Like” button to show support or agreement where the number of likers represented 89% of users where the commenter was only 9%. Only 1% were considered as a sharer of information and post author who

in this case was the moderator of the page.

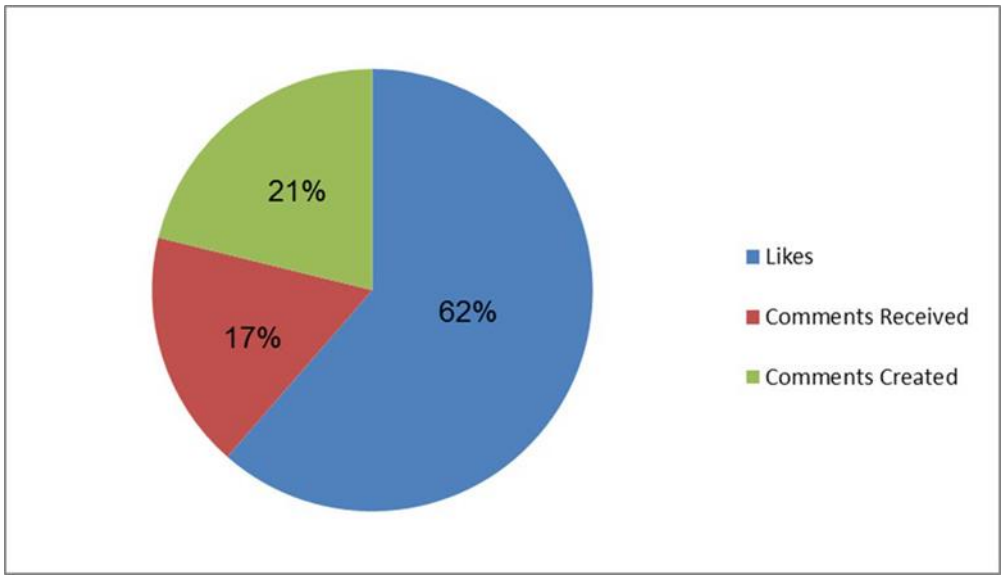


Figure 4. 5 Engagement themes between migraine patients on Facebook

As shown in figure 4.7; the different types of communication patterns between users of migraine.com Facebook page during the study period using social network analysis technique. Both the edges and the nodes are color-coded based on the “interaction type”. Edges colored in green color are ties created due to individuals commenting on each other which were represented 13%. On the other hand, the purple color edges represent ties created due to using the “Like” button. Participants use it to show support or agree with each other. This type of interaction behavior (liking) dominated by 86% over the commenting behavior which creates a question of how the technological features impact the communication between users of these online communities and how they express and ex-change support among each other. It also points out to more

research to find if this communication pattern is different across various disease condition or just exclusive to migraine patients

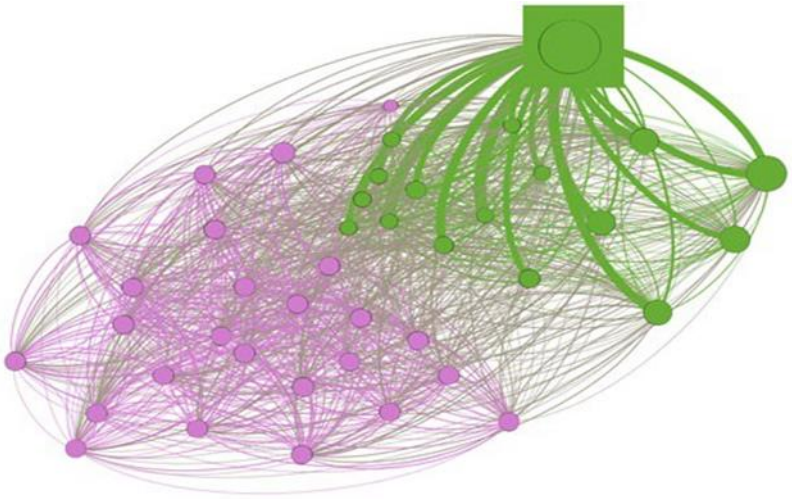


Figure 4. 6 Visualization of communication patterns among migraine community on Facebook

We were able to analyze how migraine patients on Facebook expressed and exchanged their social and emotional support to each other using the emoji features. The analysis revealed that participants showed support/agreement using the “Like” button was at the highest at 68%. Emotions expressing anger and sadness came after that at 20% and 8% respectively. Showing love and Wow” emotions were the least at 3% and 0.2% as shown in table 4.3

Likes	68 %
Angry	20%
Sad	8%
Love	3%
WoW	0.2%

Table 3 Results of using “emoji” by migraine patients on Facebook

4.3 Content Analysis of migraine.com Facebook:

The third research question asked, **RQ2:** what are the "**engagement patterns**" for migraine communities who use Twitter and Facebook? To answer research question three we coded and categorized the conversations between the community participants guided by the “Information-Community-Action” Framework.

Our analysis revealed that the conversational theme expressing information support was higher (68%) than those providing emotional support or encouragement (37%). Comments provided a call to a certain behavior or actions were the least (3%) as shown in figure 4.7. There were no advertisements or spams or inappropriate or unrelated topics which is not the case as in #migraine on Twitter.

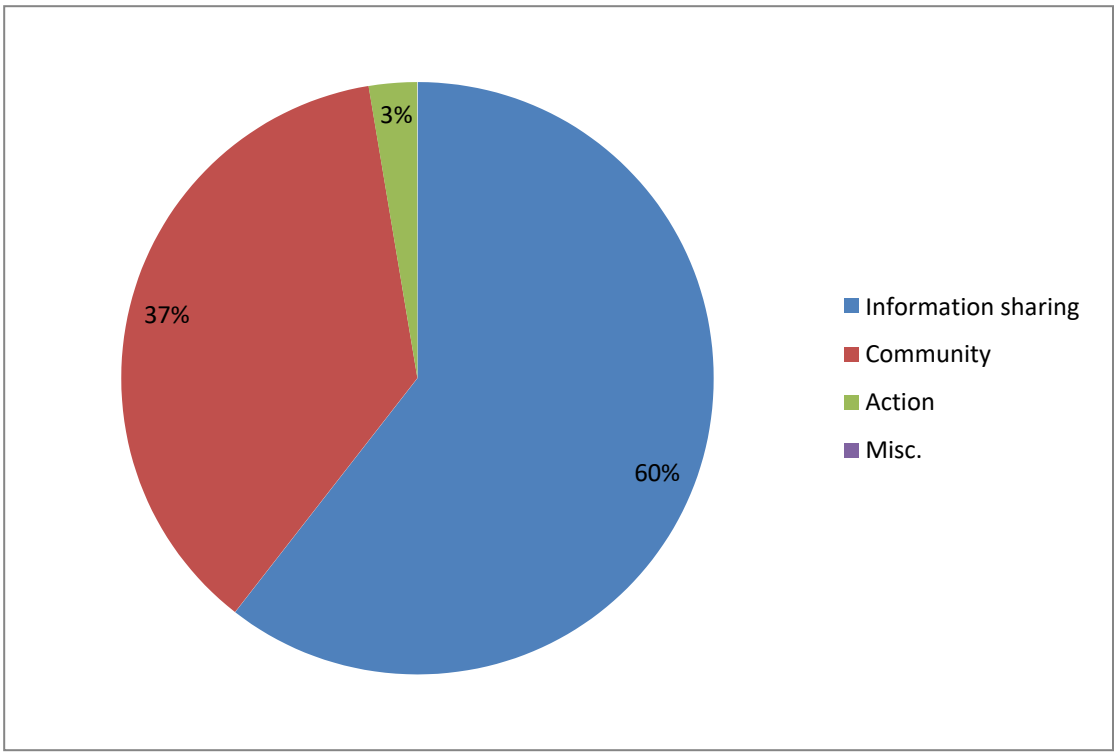


Figure 4. 7 Content Analysis of migraine community on Facebook

4.4 Content Analysis of tweets following #migraine:

To conduct content analysis, we randomly selected 300 most recent tweets in English. Guided by the “Information-Community-Action” Framework tweets were coded. Tweets provided information about migraine triggers; symptoms and personal experiences dominated by 89% (see figure 4.8)

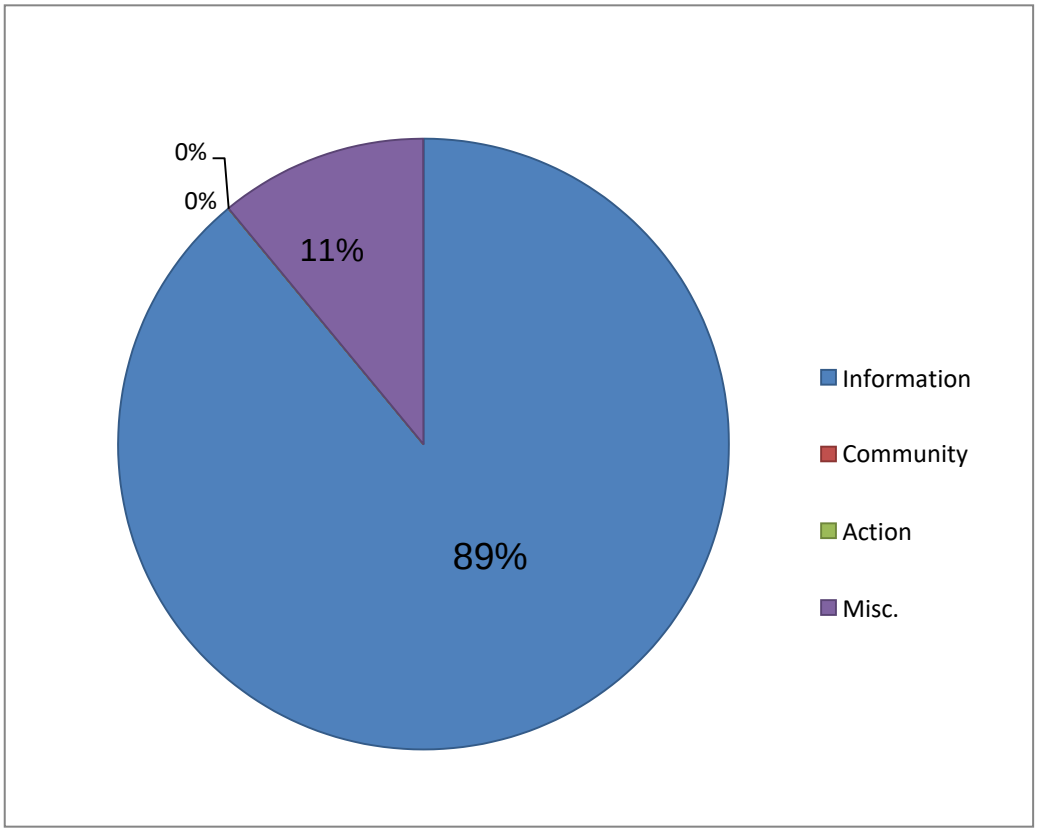


Figure 4. 8 Content Analysis of #migraine Tweets

Tweets containing miscellaneous content like spams, advertisements and unrelated topics while no tweets were providing any emotional support or call to action. We summarized, compared the coded content from the migraine communities on Facebook and Twitter in the following table

Theme	Twitter	Facebook

Information	"I have such a mi- graine but I can't stop crying." "Oh god, did I just get stabbed in the eye? Nope just another migraine day."	“Been in bed for 2 days and not able to get my head off my pillow. Sometimes my meds work and sometimes they don't” “I like this. I'm trying to figure out how to politely tell people what's going on with- out feeling like I'm whining all the time. Suggestions?”
Community	@AmandaXBob..i hope it helped you feel better after your migraine @burnhounds im sorry you’re not feeling well. you should rest as much as you can, drink water and maybe take a nyquil or exedrin migraine	I can relate to feeling like your whining but medical is- sues can be so darn annoying they de- serve to be whined about sometimes. Love you, my friend! 😵😵” This is sound ad- vice. I am constantly striving to focus on the positive.
Call for Action	Exercise and migraine:Reearch points to the importance of regular and consistent exercise as a long term https://t.co/Q7e0Bd hwIQ”	

Table 4 Coding categories for content posted on Twitter and Facebook

Discussion

It is important to highlight that there is a shortage of studies comparing patients’ behaviors on different social media platforms in general and migraine patients in

specific. For this reason, we believe that the comparative nature of the current study is considered a strength and provides a great value filling in a gap in the literature. Furthermore, this is the first study that adopts “Content” and “Social Network Analysis” techniques to analyze online migraine communities specifically. During this study, we explored and learned about the differences in social network structure and ties’ characteristics between users on each platform to reveal more about users’ communication patterns. We purposefully focused on the network connectivity and cohesiveness characteristics to compare between the migraines communities on Twitter and Facebook. And intentionally selected the “connectivity” feature due to its impact on the flow of resources and support exchanged between users whether it is information or emotional. The findings during the study period revealed that the migraine network on Twitter is denser and larger (n=9665) than the Facebook migraine network (n=292). Since denser networks exchange information through shorter pathways between the community members resulting in creating similar attitudes and behaviors. This means that overall more information and support are exchanged between users in general on Twitter than Facebook which is in-line with previous research studies [80]. The reason for that as suggested by Wellman; is that larger networks tend to generate a higher number of individuals who are willing and capable of providing support to others in the same network [2][3]. However, online users are more interested in the quality of support received is more important than the quantity [4][5].

We estimated the clustering coefficient for both communities. The clustering

coefficient is another measurement for the community connectivity from the network perspective just like the density. A network clustering estimates the intensity of “clumpiness” in the network. A social network with a high clustering coefficient denotes that participants are clumped in compact pockets of interconnectivity.

The findings reveal that the clustering coefficient on Twitter was less than Facebook (0.01 vs. 0.5). This means that there is a higher tendency of individuals on Facebook subgroups to be influenced by others’ behavior in the same subgroup and higher rates of information diffusion within the subgroups. The cluster analysis revealed that the migraine community on Facebook is clumped into three subgroups. On the other hand, followers of #migraine were clumped in 1169 subgroups. It is noteworthy to mention that Facebook subgroups are less inclined to adopt new ideas, beliefs, or introduce new behaviors due to the intensity of connectivity and clustering pertained to them. On the opposite side, the subgroups on Twitter will not be having this issue.

Therefore, from a network perspective, the migraine community on Twitter during the study period was more cohesive and denser than the migraine community on Facebook. This means that people following #migraine on Twitter has higher chances to be influenced by others opinions, beliefs and behaviors than those on Facebook migraine community. However, groups on Facebook are clumped in denser pockets than Twitter. This means that information exchanged within these subgroups is faster than between these subgroups. This situation raises a red flag as twitter is a non- monitored

platform which is not the case on Facebook migraine community which is moderated by a team that supervises what is posted or shared between participants. So the quality of the content exchanged and the advice shared is questionable which aligns with findings from previous studies [19]. So although the connectivity of the migraine community and the quantity of the content exchanged on Twitter is higher than those on Facebook; there is no guarantee that the quality of the information exchanged is better. In the previous section, we discussed the findings from the network perspective. In the following section, we get closer and shed light on the results from the individual (dyadic) level. This was crucial to gain a complete understanding and cover the different aspects of the analysis. To understand the connectivity between users on the individual level; we selected two measurements: Tie strength and Reciprocity.

Tie Strength:

As stated by Granovetter (1973:1361) tie strength is a blend of “the amount of time, the emotional intensity, the intimacy and the reciprocal services which characterize the tie”[21]. This leads to categorizing ties into three main categories: strong, weak, or absent ties. Strong ties are often associated with friends and family. Weak ties on the other hand are related to colleagues. In general, previous studies characterized online health social networks by having “weak” ties, and this is usually since individuals are seeking emotional or informational support from other participants whom they only know virtually [21]. Moreover, previous research proposed that Twitter is a platform for

health information dissemination purposes not for providing emotional support or building connections.[81] [82]. Findings from the study revealed that Individuals following # migraine on Twitter exhibited stronger ties than the migraine community on Facebook. This finding indicates that migraine Twitter users communicated and exchanged - formation relatively more than the Facebook migraine community.

Granovetter in his theory “The Strength of Weak Ties” stated that “ideas, information and influences that are socially distant” are diffused through connections that offer dissimilar resources which are backed up by another study suggesting that on the individual level, strong ties are more influential but weak ties are accountable for the propagation of new information [83]. Strong ties create a lot of redundant information because it is provided by connections that have the same resources we have. Therefore he suggests that patients will have access to useful, unavailable information through weak ties created on virtual online communities [21]. However, researchers found that the quality of support is more important than the quantity of support received.[84][85] while another study proposed that the small and everyday support actions as in the case of the one-click “Likes” are more influential in providing support[83]. In the next section, we explore the “Reciprocity” which is another indicator of the tie strength.

Reciprocity:

A reciprocated tie means that two individuals communicate equally to each other and is an indicator of the “Tie Strength” –Valente Book. In our study, the

reciprocity was higher between twitter users than Facebook. (Reciprocity=0.03 vs.0.02). This indicates that migraine patients on Twitter have stronger connections than those on Facebook. Subsequently, those on Twitter are likely to engage and be influenced by other behaviors compared to the Facebook migraine online community as proposed by previous studies [86]. In the next segment, we discuss results from the content analysis conducted on both migraine communities.

Content Analysis:

The wealth and the diversity of content generated by users on social media platforms such as Twitter and Facebook, triggered scholars to implement the "content analysis" technique to explore the conversational themes among individuals and their social network. Health-focused online communities, in general, differ from other online organizational or educational communities by the presence of social support, high use of emotional dialogue and absence of punitive language [87] which was clear from conversations between users on both communities. For example:

"It is very helpful. It's very difficult when people see you on good days to realize that you have bad days that they don't see you because you are dealing with a symptom of a migraine. To my migraine buddies, I hear your pain! There are shallow people everywhere that only see their hurts. Whatever you are experiencing, there is someone out there you can reach out to and help by hearing them".

Most online health communities' members are composed of patients sharing the same diagnosis and health condition leaning to trust each other more than

officials and professionals [88]. Furthermore, members of online health community motives from interacting with each other are gaining deep knowledge about their condition as a result of interacting with each other [89].

The Information-Community-Action Framework guided our analysis to explore the themes and compare users of Twitter and Facebook. Results revealed the domination of the informational theme on both platforms over the emotional theme and compared to the “Call to Action” which almost disappeared on both platforms. The explanation for this phenomenon is that the main goal or motivation for migraine patients is “seeking information” to help them cope or manage their chronic disease condition. Some participants wanted only to share status updates, share more details about their daily challenges with migraines, or only vent about their health condition at that specific moment. Migraine patients felt that participants in the same migraine community will relate and understand the exact sufferings more than others who don’t have migraines. What was more interesting that; despite the differences in the technical features between Twitter and Facebook. For example, the limiting characters of the tweets versus Facebook; still the informational theme dominated over the emotional and the call to action theme. However, our results come in line with previous study results [90] and are consistent with a recent study addressing the motivation of migraine patients joining online communities on Facebook[91][92]. The information support theme was composed of symptoms, triggers of migraine and daily life challenges. The information theme dominated over emotional support theme in conversations

on both platforms which resembled results from two recent studies [91][93]. The emotional theme was present between members of the Facebook migraine community and was far less on Twitter. We refer this phenomenon to several reasons;

1. Twitter is known as information dissemination or broadcasting platform than a social or emotional platform.
2. Twitter is considered a noisy platform as mentioned by Piskorski in his book “A Social Strategy” [94].
3. Twitter is full of organic, unregulated and redundant content that is posted by anonymous individuals.
4. The presence of a lot of spam and advertisements.

All the above-mentioned reasons could contribute to the absence of an emotional or social conversation theme between those suffering from migraines. From the analysis, we noticed the differences in the quality of content exchanged between users on “migraine.com” Facebook page versus Twitter. This triggered the necessity to shed light on the role of “Moderators” of the “migraine.com” Facebook page. Supported by previous research, moderators of migraine.com Facebook page provided a supportive role in many different ways;

a) Filtering the content from any unrelated, inappropriate content or spam.

Providing support and encouragement to community members. For example: “*But people DO say they have a migraine who have never had one because they think it just means "really bad headache, Which is*

frustrating". Katie Payne, good perspective, thanks for sharing with us! " **Melanie (Migraine.com team member).**

Another example; *"Hi Heather Van Fossen It certainly is enough to just suffer from a migraine! You sound like you have some great people in your life :-) Thank you for sharing with the community. Best,* **Brooke (Migraine.com Team)**

b) Also, moderators share trusted articles about migraines which triggered engagement between active participants to share their stories and daily experiences with migraines [95].

For example; "*Hi Tara Capponi* - We're glad this article resonated with you. I'm so sorry you've had to deal with people not understanding the true impact of chronic migraine and how it can interfere with one's goals. I thought this article by one of our contributors may be of interest: https://migraine.com/blog/yes-migraine-is-a-disability/. Please feel free to come here anytime for support. Best, **Brooke (Migraine.com team)/ Another Participant replied;** "Something I was having ear problems yawning didn't know it was a symptom" One of the BEST articles yet! I love this article. We are ALL strong because we ALL are suffering from a painful condition. Jamie Jean Maertens **..**very true. Thanks for joining the conversation". **Melanie (Migraine.com team member).**

On the other side, information tweeted by followers of #migraine was more organic random and contained a lot of spams and incorrect knowledge and links from unknown sources that raise a red flag. Previous studies conducting a content analysis on Twitter for various disease conditions acknowledged the presence of incorrect information which is a great hazard for public health

and has to be seriously addressed by officials [19]. Although the conversations had a less emotional theme in both migraine communities, users of the migraine community on Facebook took advantage of the features available and preferred to utilize the “emoji” to express their different feelings more than commenting and provide support to others. Almost 90% of their communications pattern focused on using one of these emoji buttons rather than taking the time to write a supportive or encouragement comment which is in line with findings from a recent Australian study [90]. For example, users used the “Like” button to show agreement or support others used the “angry”, “Sad” or the “love” buttons. On the other hand, Twitter doesn’t have the same features as “emoji” and are not utilized as much as in the case of Facebook. This leads to more unanswered questions regarding the impact the technical features exclusive to each social media platform and how it affects the migraine patient’s usability

Also, whether it is related to specific behavioral change and to what extent?

One unique finding on the Twitter migraine community was the existence of many calls to participate in research studies and advertisements for migraine treatments. It is still unclear how the use of Twitter for these objectives is beneficial for the patient and organizations posting these ads or research calls. As mentioned before the important role of moderators of the Facebook migraine community in eliminating all the spams, incorrect information and creating a trustable safe environment which is valuable and vital for the sustained engagement between users of the community which aligns with

previous research findings [95]. On the other hand, Twitter as a platform provider and the lack of a moderator contributed to the high volume of inappropriate tweets, misinformation and spams which was no difference from results from previous studies[19][93]. Parallel to previous research and resembling other patients in chronic health conditions[96][97], the tweets of #migraine followers was somewhat personal and reported instant health status updates or feelings for example; “I feel horrible”. Calls for action or performing a specific behavior to cope with migraines were the least theme after the emotional and information conversational themes.

Differences in technical features between Twitter and Facebook and impact on users’ communication patterns and support exchanged;

Facebook and Twitter have different technical features that are unique to each platform. Researchers found that online communities on different social media platforms deliver different benefits to patients leading to diverse results in their health outcomes. Patients’ selection of a specific type of platform is influenced by their needs and motives [92].

Yet, there is ambiguity in the area of the intersection of technology, disease condition and patients and how it relates to changes in health behavior and health outcomes [98]. It is hard to ignore the impact of these differences on their users’ communication patterns and patients, in general, are no exception. Since the broad objective of the study was to identify differences in communication patterns of migraine members; it would be valuable to shed light and share some of the communication and usage patterns observed.

These observations would need future investigation and scholarly attention. In this section, we rely on research performed by scientists from the “Information Sciences” domain. Their findings drew attention to the role of users' emotions as one of the factors impacting their decision to adopt and utilize a specific technology [99][100].

First: Despite that the informational support theme dominated over the emotional support theme in both communities; tweets generated by Twitter users were somewhat shorter than those posted on migraine community on Facebook. From this pattern, we can observe the impact of the unique technical features on Twitter as it limits the tweet to a maximum of 140 characters. On the other side, Facebook's lack of this limited content feature, allowed the migraine community to post longer sentences, with more details exposing more of their sufferings with the disease. The postings of the migraine community members on Facebook had a narrative and storytelling style compared to migraine Twitter users which were more of venting or ranting *“some- times death seems better than the migraine in my head”*. The question raised here; does the unique features to each platform attracted those types of patients that are inclined to share details about their daily sufferings with migraines or is it the opposite way.

Second: the availability of Facebook “emoji” features provided the opportunity and convenience to its users to express a diversity of feelings and provide support to others in the community with just “one click” i.e. the least effort exerted to provide support to others members on Facebook showed support to others

using the “Like” button “Likers” represented 89% vs “commenters” that only represented 9%. It is noteworthy to highlight the fact that only 292 active participants out of the 124,000 community members (0.2%) creating 189 posts and 25,146 ties Most of these ties were created by the least effort (using the emoji buttons) and provided a “one click” but consistent support to other migraine community members. This type of support has been reported to be most influential and reassures continued engagement among community members [101].The effectiveness of the “one click” support raised the following questions; a) is it an accepted and expected culture for the Facebook users in general and migraine patients are not exceptional? b) Does this type of “one click” support really satisfy a need for the Facebook community members in general and migraine patients in specific? C) Was this unique feature to the Facebook platform “one click support” one of the factors that impacted migraine community members decision to join the group and why? D) how long would they stay in this community?

Third: We noticed that for the same study period, there was a big difference in the quantity of content generated on both platforms. The migraine community on Twitter had higher content than Facebook (9,665 tweet vs 189 posts) despite the limited number of characters for tweets on Twitter. The presence of big number tweets containing spam, advertisements in addition to unrelated and inappropriate tweets. So although the larger quantity of content generated on Twitter compared to Facebook posts doesn’t necessary means good quality content that satisfy the migraine com- munity needs on Twitter. This could lead

to question if migraine patients on Twitter could be overwhelmed by the amount and quality of tweets or does twitter acts as enabler for them to just vent to others having the same condition without revealing their identity? Subsequently, this would question the participation regularity by users in Twitter vs Facebook and how long do they stay or drop off these communities.

Significance:

The study findings contribute to a growing body of literature addressing the differences in patients' behavioral patterns on various different social media plat- forms. A lot of interest has grown recently from scholars investigating chronic patients appropriation of specific type of technology in general [98][90]. We believe the study fill a gap in research for migraine disease specifically which is a chronic debilitating disease impacting the quality of life, productivity and require a lot of self-management and coping efforts [102]. As we learn about patients' behaviors on different social media platforms, the more public health officials which tools they leverage to reach specific type of patients or disease conditions and successfully address their issues. Consequently this will result in improved health outcomes, reduce public spending on chronic disease management and support good patient- physician relationships [103][99][90]. Moreover, effective use and design of these social media platform could contribute to lowering the costs of chronic disease management while enhancing the quality of health services provided [99][104]. Additionally, this could educate healthcare providers about the specific patients' needs, utilization patterns and motivations to adopt a specific platform which will lead

to addressing disparities in delivering health services[99].The findings will inform healthcare professionals and intervention designers to select the appropriate platform with specific technical feature that address the unique needs for migraine patients. This would vastly benefit online migraine patients using social media platforms in several ways; a) reduce their feeling of stigmatization and loneliness within the society, b) enhancing the quality of information provided and exchanged, c) It is the first study to study the characteristics of the social network and type of relations between users of a migraine community.

We take it further to compare between two migraine communities on two different social media platform (Facebook & Twitter). We used content analysis to identify conversational themes developed between participants and compared across Facebook and Twitter. Despite the escalating interest from scholars to understand the role of social media tools in health behavior, there are still a lot of questions remain unaddressed and require scholars from different domains to come together to contribute to this area of research. For migraine specifically, its serious economic and social impact from an individual and a public health level, make it that needs more attention not only from a clinical perspective but also from a social and behavioral approach. Migraine requires a lot of self-management and effort from the patient to avoid triggers, be prepared to cope with their unique symptoms which could last from several hours up to few days. The study is a first step that will need more investigation to build on from scholars interested in this domain. Considering all of the above

mentioned, this study attempted to understand how migraine patients act, communicate and need from two different social media platforms.

The moderated Facebook migraine community was privileged by the access to information from trusted resources in addition to the continuous encouragement from the team of administrator managing the community. On the other hand the migraine community on Twitter which was not moderated was characterized by the spread of misinformation, negativity, advertisements and spam. These findings on Twitter were consistent with findings of previous studies. This is where the benefits of having moderated communities versus unmoderated arising and should be taken in consideration especially from a practical side. Furthermore, it educates online community managers, public health officials and health organizations like FDA about the needs of migraine patients and why they use these tools which are to exchange information and emotional support to help them cope with migraine episodes.

Strengths and weakness of the study:

Given the scope of this project, several limitations were accrued. Content analysis selected English conversations either on Twitter or Facebook eliminating other languages. Consequently, posts from users from other countries and cultures were not studied which could carry different themes. Therefore, our data and results may not represent a non-English speaking migraine population. About methods available for analyzing Twitter, we were only able to collect public tweets. It is a definite fact that some users of social

media platforms voluntarily choose to keep their postings private. Another limitation that we may have accumulated is that we were only able to collect information from an active participant and the rest of the communities (lurkers) remain unknown and unstudied. The differences in results between might have been impacted by the variation in demographics characteristics and preferences for a specific platform. Twitter has been known to be more appealing for younger, tech-savvy individuals while Facebook has been recently more favorable for the older population [6]. For analysis, we only focused on “directed tweets”; future research should include undirected tweets to uncover the content of these tweets which may alter findings.

Directions for future research:

This study provides opportunities for future research to build on. From social network analysis, future work should include other measurements like changes in the communities’ overtime, duration of the community membership. The study period should be extended to explore different insights. More research may be needed in offline settings to enhance the understanding and compare the impact of emotional and informational in real life meet the same needs as in the case of online communities.

Knowledge revealing the overall characteristics of the population participating in a specific platform (tech. savvy, age, gender) would be a great research opportunity. Other research questions needed to be addressed about the impact of participating in moderated community vs a non- moderated one.

Furthermore, the rigorous investigation is needed to show whether the technical features specific to a certain social media platform impact the patients' engagement and behavior and to what extent.

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